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FINAL REPORT

CONTRACT NO. N00024-71-C-1246

SUPPORT TASKS FOR TRANSDUCER ANALYSIS AND DIFFRACTION INVESTIGATIONS

Submitted to:

Commander
Naval Ship Systems Command
Department of the Navy
Washington, D.C.
Code 12052

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1.0 INTRODUCTION

This report describes the work performed by Radian Corporation on Contract No. N00024-71-C1246 from 1 July 1971 to 1 September 1972. This work consisted of on-site support to Naval Undersea Research and Development Center (NUC) personnel in the area of sonar transducer analysis and design. In addition, work was performed to investigate the effects of diffraction and transmission characteristics of planar baffles on passive array performance.

2.0 TRANSDUCER ANALYSIS AND DESIGN

This section describes the work performed in the on-site support to the Transducer and Array Systems Division of NUC, San Diego. This work involves the computer-aided transducer analysis and design using SEADUCER (Steady-state Evaluation and Analysis of TransDUCERs). This computer model is designed to model any linear system which can be described as an interconnection of multi-port networks; however, its function for this contract was related strictly to sonar transducers. The on-site support included the following tasks:

- Reformat magnetic tapes supplied to NUC by General Dynamics/Electric Boat Division that contained impedances and velocities to be compatible with SEADUCER input format.
- Design and set up SEADUCER runs to analyze the properties of the 3C5 transducer elements varying the element configuration.
- Review documentation of Modest Improvement Plan (MIP) for the TR-208 active transducer element.
- Convert SEADUCER from UNIVAC 1108 EXEC 8 to UNIVAC 1108 EXEC II, and execute several example runs.

Reformatting the 9 track magnetic tapes to a format compatible with the SEADUCER input format was accomplished via subroutines written for the NUC UNIVAC 1108 facility. The data on the tapes supplied by GD/EB were impedance matrices and

velocities for different heads for the 3C5 transducer. The impedances matrices were reduced to determine an array of unique impedances to be used in the computation of various performance variables as a function of frequency. This process was done to reduce the computation time associated with the performance variables.

Radian assisted NUC personnel in the design and set-up of a single frequency design run to analyze the 3C5 element (Run No. 80168). The analysis consisted of examination of the element without a can, and then adding the can and mounts to determine their effect on the element performance. The 3C5 element was also analyzed with different transducer heads that were designed by GD/EB.

The documentation of the Modest Improvement Plan was reviewed by Radian. This documented work performed by NUC and assisted by Radian for improvement at the performance of the TR-208 active transducer element. The analysis consisted of computed critical performance variables as a function of frequency and displaying these via a Calcomp plotter.

The SEADUCER computer model was implemented at the Radian facility which utilizes a UNIVAC 1108 operating under the EXEC II operating system. This required some minor changes in control cards from the NUC UNIVAC 1108 EXEC 8 version. Radian converted the magnetic tape supplied by NUC using a program supplied by UNIVAC. After conversion of the tape, the model was checked by running the example runs that are included in the SEADUCER model documentation. Two of these example runs are included in Appendix A.

3.0 DIFFRACTION INVESTIGATIONS

This section describes the support effort that Radian has provided in connection with NUC investigations on passive-array baffle design. These efforts have been concerned with developing a computer model to investigate the effects of diffraction and transmission characteristics of planar baffles on passive-array performance.

The modeling efforts represent one facet of an overall exploratory development program whose objective is to provide design guidelines for improved baffles to enhance the low frequency, passive performance of wide aperture arrays. Due to the increased size and weight requirements associated with extending the conventional puffs baffle concept to lower frequencies, the goal of the development effort is to examine possible alternatives to design a functional baffle which is effective in shielding the array from internal machinery noise and simultaneously enhances low frequency, passive-array performance.

In connection with this program, Radian's support efforts have involved development of a computer model to characterize the scattering and transmission properties of planar strip baffles. To date a working computer model has been developed for calculating the pressure field in the vicinity of a planar baffle which accounts for the combined effects of transmission and diffraction from a half plane. A version of this computer program is operational on the UNIVAC 1230 at NUC and is being used in conjunction with an experimental investigation of scattering from rectangular plates of various materials for a wide range of frequencies. In addition, this model is currently being generalized to treat the case of a planar strip baffle according to the approach outlined in Appendix B.

These efforts represent an initial attempt, as part of a continuing investigation, toward the synthesis of a valid composite math model to perform parametric analyses of significant baffle parameters on performance of passive-arrays.

Appendix A

Examples of SEADUCER Run Under UNIVAC 1108 EXEC II.

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This appendix shows examples of the SEADUCER model run under UNIVAC 1108 EXEC II. The purpose of this task was to demonstrate that the SEADUCER model was written in standard FORTRAN and could operate under different operating systems, and also on different types of computers. The task also made available to potential users of the model a version that had compiled and executed correct under the EXEC II operating system.

The first example presented here is a single frequency transducer element design. The transducer element is described by defining network interconnections and specifying individual network types. Then for a variety of tail lengths, ceramic areas, and ceramic lengths, the problem is to determine the number of ceramic pieces required to minimize the voltage-velocity control impedance, Z_{ec}. The second example is strictly a matric calculation for a given transducer element configuration, and was included since it checks many of the features of the model.

```
[illegible] CONTRL/S,CONTRL/S,CONTRL/R                                              16:56:13.541
UNIVAC 1108 FORTRAN V LEVEL 2205 0023

MAIN PROGRAM

STORAGE USED (BLOCK, NAME, LENGTH)

      0001    *CODE     001153
      0000    *DATA     [illegible]
      0002    *BLANK    [illegible]
      0003    CATALG    001075
      0004    BARIOS    000006
      0005    STATOT    000001
      0006    TOTL      000002
      0007    [illegible] [illegible]
      0010    [illegible] [illegible]
      0011    [illegible] [illegible]
      0012    COESGN    000005
      0013    SMECIC    000020
      0014    CRMPCT    000004
      0015    [illegible] [illegible]
      0016    [illegible] [illegible]
      0017    [illegible] [illegible]

EXTERNAL REFERENCES (BLOCK, NAME)

    0020   PAGE          0021   STRLIN        0022   LDFCRT        0023   LDDT1         0024   LDDT4
    0025   LDDT7         0026   ALOCAT        0027   SKPLIN        0030   LDIMTR        0031   HEAD24
    0032   LDFREQ        0033   BLOKKL        0034   RDCPRT        0035   LDDT11        0036   FNDTL
    0037   LDCMTR        0040   [illegible]   0041   PRTMTR        0042   LDAM2S        0043   CMPGAM
    0044   [illegible]   0045   [illegible]   0046   [illegible]   0047   [illegible]   0050   PRPTBL
    0051   [illegible]   0052   [illegible]   0053   [illegible]   0054   [illegible]   0055   NWDCS
    0056   [illegible]

STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

 0001    000067 100L        0000    000407 149F        0000    000427 150F        0000    000431 152F
```

```
0001     001006 1ROL      0001     001071 200L      0001     000434 2330      0001     000453 2400
0001     000514 2543      0000     000077 5F        0001     000632 99L       0000 R 000005 C3D4R
0002 D 000000 DATA      0004 D 000000 DF        0000 D 000065 DFBAND    0013 D 000002 DGECI
0000 D 000052 DGECMG    0000 D 000040 DGECMN    0013 D 000000 DGECR     0013 D 000006 DGICI
0013 D 000004 DGICR     0000 D 000055 DLC3D     0000 D 000001 DLMIN     0000 D 000057 DMGNE
0004 D 000000 DMEGA     0004 D 000004 DPI       0014 D 000002 DREACT    0014 D 000000 DRM
0006 D 000000 DTL       0007 D 000000 DTMASS    0013 D 000012 DZECI     0013 D 000010 DZECR
0013 D 000016 DZICI     0013 D 000014 DZICR     0000 R 000030 FACTOR    0000 I 000051 IA42D
0000 I 000075 IAY2Z4    0003 I 001274 ICLGSB    0000 I 000034 ID2S      0016     000001 ICCIC
0016 I 000003 IFLGLC    0016     000002 IFLGSP    0011 I 000000 IFMNPR    0000 I 000031 IFORM
0000 I 000003 IFC       0016     000000 IMXMN     0003     000310 IPC       0000 I 000032 IPUNCH
0000 I 000035 IGDS      0003     000310 ITYPE     0000 I 000050 IZA2D     0000 I 000076 IZY2Z4
0000 I 000023 L         0000 I 000012 LNAMES    0003 I 002130 LOC       0037 I 000000 LOCMTR
0000 I 000016 LR2D1     0000 I 000074 LYZ       0000 I 000024 M         0017 I 000001 MAXSKP
0000 I 000042 MINCNT    0017     000000 MINSKP    0015 I 000000 MTRGVN    0003     000144 MTRSIZ
0005 I 000000 MXDATA    0000 I 000045 N         0003     000000 NAME      0003     000764 NDTSTR
0010 I 000000 NIPOT     0003     000454 NPCTOT    0012 I 000003 NPGEMN    0000 I 000044 NPHI
0000 I 000143 NPLO      0000 I 000025 NIMCS     0017 I 000002 NIPOLO    0017 R 000002 RAC3D
0012 R 000004 RAR2D1    0000 R 000037 RAY2Z3    0000 R 000073 RGECMN    0000 R 000067 RGICMG
0000 R 000046 RLC3D     0000 R 000054 RLGEMN    0012 R 000000 RLR2A1    0000 R 000047 RLR2D1
0012 R 000001 RLR2Z1    0000 R 000035 RLT2A1    0000 R 000027 RLY2Z4    0000 R 000026 RMY2Z4
0000 R 000071 RPGEMN    0000 R 000070 RREACT    0000 R 000064 RTL       0000 R 000072 RTLC3D
0000 R 000033 RTMASS    0000 R 000000 TZAIL


00101      1*          IMPLICIT DOUBLE PRECISION (D)
00103      2*          COMMON / CATALG / NAME(100), MTR SIZ(100), I PC(100),
00103      3*         1     N PC TOT(100), I TYPE(100), N DT STR(100), LOC(100), I CLG SB
00104      4*          COMMON / BASIC 3 / D F, D OMEGA, D PI
00105      5*          COMMON / DTA TOT / MX DATA
00106      6*          COMMON /          / DATA(1310)
00107      7*          COMMON / TOT L / DT L
00110      8*          COMMON / TOT MAS / DT MASS
00111      9*          COMMON / PCT OFF / NO PCT
00112     10*          COMMON / C FMN PR / I FMN PR
00113     11*          COMMON / CDESGN / RL R2A1, RL R2Z1, RA C3D, NP GE MN, RA R2D1
00114     12*          COMMON/ GM EC IC /DGECR,DGECI,DGICR,DGICI, DZECR,DZECI,DZICR,DZICI
00115     13*          COMMON / C RM RCT / DRM, DREACT
00116     14*          COMMON / C SPMTR / MTR GVN
00117     15*          COMMON / FLG SPH / I MX MN, I CC IC, I FLG SP, I FLG LC
00120     16*          COMMON / CMN FMN / MIN SKP, MAX SKP, NI POL D
```

```
      DIMENSION T2A1 L(5)
      DIMENSION C3D AR(5)
      DIMENSION L NAMES(4)
      DIMENSION L R2DI(5)
      DATA (L NAMES(L), L=1,4 ) / 'TA','CD','EE','YZ' /
      DATA (L R2DI (L), L=1,3 ) / 'VW','DE','CD'          /
      DATA ( C3D AR(M), M=1,5 ) / .0049, .0065, .00752, .0091, .012898 /
      DATA( T2A1 L(L), L= 1, 5 ) /
     / .0381247, .0762493, .114374, .152499, .190623 /
      DATA N1 HOS / 1 /
      MX DATA = 1310

      CALL PAGE
      CALL STP LIN
      PRINT 5
    5 FORMAT(' MOD 8 RUN 80038 APR 23, 1970 $ LIKE MOD 7 RUN 70335'/
     /        '  DESIGN RUN 8'/
     /        ' LINES OF CONSTANT TAIL LENGTHS' /
     /        ' CHARGE TO 10000501 ARRAY DESIGN'    )

      CALL LD PORT ( 'S', '1B7D, -+1T1A, -+1R2A,$' )
      CALL LD PORT ( 'S', '2B7D,    1E2E,$' )
      CALL LD PORT ( 'S', '3B7D,    2Z2A,$' )
      CALL LD PORT ( 'S', '4B7D,    1P2P,$' )
      CALL LD PORT ( 'S', '5B7D,    2Y2Z,$' )
      CALL LD PORT ( 'S', '6B7D, -+2C2E,    1V2W,  1Y2Z,$' )
      CALL LD PORT ( 'S', '7B7D, -+1T1B,    2R2Z,  2V2W,$' )

      CALL LD PORT ( 'S', '1A6D,    3C2D,$' )
      CALL LD PORT ( 'S', '2A6D,    5E5D,$' )
      CALL LD PORT ( 'S', '3A6D, -+2C3D,    2B5D,$' )
      CALL LD PORT ( 'S', '4A6D, -+1B5D,    1C3D,$' )
      CALL LD PORT ( 'S', '5A6D, -+3B5D,    1R2D,$' )
      CALL LD PORT ( 'S', '6A6D, -+4B5D,    2P2D,$' )

      CALL LD OT1('E2E1S',4416.00,1.44261E-2,0.,0.,.0090693,4620.,0.,0.)
      RL R2A1 = .0072484
      CALL LD OT1('R2A1S',7702.80,7.90233E-4,0.,0.,.0072484,4970.,0.,0.)
      RL R271 = .0008379
      CALL LD OT1('R271S',7702.80,7.90233E-4,0.,0.,.0008379,4970.,0.,0.)
      CALL LD OT1('T2A1S',7700.00,2.30338E-3,0.,0.,.0033570,4970.,0.,0.)
      CALL LD OT1('T2B2S',7724.57,1.64002E-3,0.,0.,.0033140,4970.,0.,0.)
      CALL LD OT1('T2B3S',7719.24,1.30693E-3,0.,0.,.0102145,4970.,0.,0.)
```

```
      CALL LD DT1('T234S',7702.80,7.90273E-4,0.,0.,.0056790,4070.,0.,0.)
      CALL LD DT1('V2W1S',4416.90,1.12775E-2,0.,0.,.0113701,4820.,0.,0.)
      CALL LD DT1('V2W2S',4416.90,1.12776E-2,0.,0.,.0113701,4820.,0.,0.)
      CALL LD DT1('V2W3S',7788.49,2.54934E-3,0.,0.,.0022244,5116.,0.,0.)
      CALL LD DT1('Y2Z1S',2712.81,3.46113E-3,0.,0.,.0113701,5200.,0.,0.)
      CALL LD DT1('Y2Z2S',2712.81,3.46113E-3,0.,0.,.0113701,5200.,0.,0.)
      CALL LD DT4('Y2Z3S' )
      CALL PAGE
      RM Y2Z4 = 2.755
      RL Y2Z4 = .04516
      FACTOR = 1.
      I FORM = 0
      CALL LD DT 7( 'Y2Z4S', FACTOR, I FORM)

      IPUNCH = 1
      IPUNCH = 0
      MAX SKP = 1
      NI POL D = 1

      CALL ALOCAT('FS', 2, 8)
      IF2S = LOC(I CLG S8)
      CALL ALOCAT('DS', 2, 8)
      ID2S = LOC(I CLG S8)
      CALL ALOCAT( 'SS', 2, 8)
      IS2S = LOC(I CLG S8)
      CALL SKP LIN(1)
      CALL LD I MTR(IF2S, 2)
      CALL HEAD 24(' F2S UNIT MATRIX        ')
      CALL LD I MTR(ID2S, 2)
      CALL HEAD 24(' D2S UNIT MATRIX        ')
      CALL LD I MTR(IS2S, 2)
      CALL HEAD 24(' S2S UNIT MATRIX        ')

      CALL PAGE
      CALL LD FREQ ( 3500.00 )

      DO 300 L = 1, 5
      RL T2A1 = T2A1 L(L)
      CALL LD DT1('T2A1S',7932.48,2.17225E-2,0.,0., RL T2A1,5116.,0.,0.)

      DO 200 M = 1,5
      RA C3D = C3D AR(M)
      RAY2Z3 = RAC3D * 0.5
```

```
      CALL LD DT1('Y2Z3$',2702.61,RAY2Z3 ,0.,0.,.0353544,5200.,0.,0.)
      CALL BLD KKL('B7D$')
      CALL RDC PRT( 'B 7D$', 'B5D$' )

      DGECMN = 1.E30
      MIN CNT = 0
      NP LO = 2
      NP HI = 26

      DO 100 N = NP LO, NP HI, 2
      RL C3D = .0139253
      CALL LD DT 11('C3D$',N,7508.21, RA C3D ,0.0,0.0, RL C3D,
     E .1411656D4, 0.00, .2419850-2,
     G .2452070-1, 0.00, -.1974270-3,
     S .9404950-11, 0.00, .1570290-2 )
      CALL FND T L ( L R2D1, 3 )
      RL R2D1 = CT L - RL R2A1 - RL R2Z1
      RA R2D1 = 5.71140E-4
      CALL LD DT1('R2D1$',7702.90, RA R2D1 , 0.,0., RL R2D1,4970.,0.,0.)
      IF ( NO PRT .EQ. 0 ) CALL PAGE
      NO PRT = 0
      NO PRT = 1

      CALL BLD KKL('A6D$')
      CALL RDC PRT( 'A6D$', 'A2D$' )

      IZA2D = LOC MTR('AD', 2)
      IAA2D = IZA2D+9
      CALL Z TO A(IZA2D, IAA2D)
      IF ( NO PRT .NE. 0 ) GO TO 99
      CALL HEAD 24(' A A2D                    ')
      CALL PRT MTR(IAA2D, 2)
   99 CONTINUE

      CALL LD A M2S
      CALL CMP GAM(IAA2D)
      DGECMG = DSQRT(DGECR**2+DGECI**2)
      IF ( DGECMG .GE. DGECMN ) GO TO 100
      DGECMN = DGECMG
      PLGE MN = RL C3D
      NPGEMN = N
      MIN CNT = MIN CNT + 1
  100 CONTINUE
```

```
      IF( MIN CNT .LT. 2) CALL HEAD24(' NO MIN GAM EC                    ')
      IF ( MIN CNT .LT. 2 ) GO TO 200
      I FMN PR = 1
      I FMN PR = 0
      DL C3D = RL GE MN
      CALL FMFN( DL C3D, DNONE, DNONE, DL MIN, DGECMN )

      CALL FND T MS
      RT MASS = DT MASS + RM Y224
      CALL FND T L ( L NAMES, 4 )
      RT L = DT L + RL Y224
      IF ( NO PPT .EQ. 0 ) CALL PAGE
      DRM = 1.D-30
      DF BAND = 3500.00
      MTR GVN = 1
      CALL SR MID6( DF BAND,                    'MAX', 'IC', 'P', DRM )
      I FLG LC = 0
      RGICMG = DSQRT(DGICR**2+DGICI**2)
      RREACT = DREACT
      RPGEMN = NPGEMN
      RTLC3D = DL MIN * RPGEMN
      RGECMN = DGECMN
      IF ( NI HDG .EQ. 0 ) GO TO 160
      NI HDG = 0
      CALL SKP LIN(1)
      PRINT 149
      IF(IPUNCH.NE.0) PUNCH 5
      IF(IPUNCH.NE.0) PUNCH 149
  149 FORMAT(       '  L T2A1    A C3D     L C3D   TOT MASS  TOT LENGTH',
     /    '  REACTOR  GAMMA IC GAM EC MIN' )
  160 CONTINUE
      IF(IPUNCH.NE.0) PUNCH 150,RL T2A1,RA C3D,RTLC3D,RTMASS,RTL,RREACT,
     1            RGICMG,RGECMN
      PRINT 152, RL T2A1, RA C3D, RTLC3D, RTMASS, RTL, RREACT,
     1             RGICMG, RGECMN,NPGEMN
  150 FORMAT( 8E10.4)
  152 FORMAT( 8E10.4, /21X, 'N =', I3 )

  200 CONTINUE
C 200 EXIT C3D AREA LOOP

      CALL SKP LIN(1)
  300 CONTINUE
```

```
C 300 EXIT T2L LENGTH LOOP

      CALL FND NAM('YZ','LYZ)
      IAY2Z4 = LOC(LYZ+4)
      IZY2Z4 = IAY2Z4 + 8
      CALL SKPLIN(2)
      CALL HEAD 24('    4 Y2Z4                              ')
      CALL PRT MTR(IA Y2Z4,2)
      CALL SKPLIN(2)
      CALL HEAD 24('    Z Y2Z4                              ')
      CALL PRT MTR(IZ Y2Z4,2)

      CALL PAGE
      CALL PR PTBL
      CALL PAGE
      CALL PR CTLG
      CALL PAGE
      STOP
      END

   END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
 CONTRL  S       SYMBOLIC              23 JUN 71  14:23:29   0  00273476   14    94  (DELETED)
 CONTRL  R       RELOCATABLE           23 JUN 71  14:23:29   1  00276142   48     1  (DELETED)
                                                             0  00276222   14    70
```

```
I FOR RLIMMG/S.RLIMMG/S.RLIMMG/R                                              16:56:21.112
UNIVAC 1108 FORTRAN V LEVEL 2206 0023

 SUBROUTINE RLIMMG      ENTRY POINT 000167

 STORAGE USED (BLOCK, NAME, LENGTH)

        0001    *CODE     000205
        0000    *DATA     000104
        0002    *BLANK    000310
        0003    COMNPR    000001
        0004    PRTOFF    000001
        0005    TOTL      000002
        0006    GMECIC    000020
        0007    COESSN    000005

 EXTERNAL REFERENCES (BLOCK, NAME)

   0010   DSQRT          0011   PAGE          0012   LODT11        0013   FNDTL        0014   LODT1
   0015   BLDKKL         0016   RECPRT        0017   LOCMTR        0020   ZTOA         0021   HEAD24
   0022   PRTMTR         0023   LOAM2S        0024   CMPSAM        0025   PRMARI       0026   NERR3$

 STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

  0001   000121 9L        0002 D 000000 DATA      0006 D 000002 DGECI     0006 D 000000 DGECR
  0006 D 000006 DSICI     0006 D 000004 DSICR     0010 D 000000 DSQRT     0005 D 000000 DTL
  0006 D 000012 DZECI     0006 D 000010 DZECR     0006 D 000016 DZICI     0006 D 000014 DZICR
  0000 I 000013 IAA2D     0003 I 000000 IFMNPR    0000   000072 INJP$     0000 I 000012 IZA2D
  0000 I 000005 L         0017 I 000000 LOCMTR    0000 I 000000 LR2D1     0000 I 000007 N
  0000 I 000006 NOPREV    0004 I 000000 NOPRT     0007 I 000003 NPGEMN    0007 R 000002 RAC3D
  0007 R 000004 RAR2D1    0000 R 000010 RLC3D     0007 R 000000 RLR2A1    0000 R 000011 RLR2D1
  0007 R 000001 RLR2Z1

 00101      1*          SUBROUTINE RLIMMG(DX, DRL, DIM, DMG)
```

```
      DOUBLE PRECISION DX, DRL, DIM, DMG
      DOUBLE PRECISION DATA
      DOUBLE PRECISION DSQRT
      COMMON /          / DATA (100)
      COMMON / C GMN PR / I FMN PR
      COMMON / PRT OFF / NO PRT
      DOUBLE PRECISION DT L
      DOUBLE PRECISION DGECR,DGECI,DGICR,DGICI,DZECR,DZECI,DZICR,DZICI
      COMMON / TOT L / DT L
      COMMON/ GM EC IC /DGECR,DGECI,DGICR,DGICI,DZECR,DZECI,DZICR,DZICI
      COMMON / CDESGN / RL R2AI, RL R2ZI, RA C3D, NP GE MN, RA R2D1
      DIMENSION L R2D1(5)
      DATA (L R2D1 (L), L=1,3 ) / 'VW','EE','CD' /
      NO PR SV = NO PRT
      NO PRT = 1 - I FMN PR
      IF ( NO PRT .EQ. 0) CALL PAGE
      N = NP GE MN
      RL C3D = DX
      CALL LD DT 11('C3D$',N,7588.21, RA C3D ,0.0,0.0, RL C3D,
     E .141166E04, 0.D0, .241985D-2,
     G .245207D-1, 0.D0, -.187427D-3,
     S .949495D-11,0.D0, .167029D-2)
      CALL FND T L ( L R2D1, 3 )
      RL R2D1 = DT L - RL R2AI - RL R2ZI
      CALL LD DT 1('R2D1$',7702.30,RA R2D1,0.,0.,RL R2D1,4970.,0.,09)
      NO PRT = NO PR SV
      CALL SLC KKL('A6D$')
      CALL RDC PRT('A6D$', 'A2D$' )
      IZA2D = LOC MTR('A2', 2)
      IAA2D = IZA2D+2
      CALL Z TO A(IZA2D, IAA2D)
      IF ( NO PRT .NE. 0 ) GO TO 9
      CALL HEAD 24('A A2D                 ')
      CALL PRT MTR(IAA2D, 2)
    9 CONTINUE
      CALL LD A R2S
      CALL CMP GAM(IAA2D)
      DRL = DGECR
      DIM = DGECI
      DMG = DSQRT(DRL**2+DIM**2)
      IF ( I FMN PR .EQ. 0 ) RETURN
      CALL HEAD 24(' GAMMA EC             ')
      CALL PR MARI(1, 'DEG', DRL, DIM)
```

```
00157     4F*          RETURN
00160     4F*          END

     END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
  PLINMG  S          SYMBOLIC                 23 JUN 71  14:25:41   0  00613172    14     40  (DELETED)
  PLINMG  R          RELOCATABLE              23 JUN 71  14:25:41   1  00614252    36      1  (DELETED)
                                                                    0  0061431E    14     10
```

```
@XQT CONTRL/R                                                                                       16:58:22.38

        BLANK COMMON        156704        163777

        STARTING ADDRESS   014000

        CORE LIMITS 014000 050240      100000 114504      156676 156703


CONTRL/R                  NSTOPS/RL22                DSQRT /RL22                NERR$ /RL23                SQRT  /RL22
0   100000-100564         1   015153-015164          1   015165-015222          0   100577-100736          1   015757-016021
1   014000-015152                                    2   100565-100576          1   015223-015756          2   100737-100744

NIER$ /RL23               NEMTS /RL23                NFTV$ /RL22                NCNVTS/RL23                NOTINS/RL23
0   100745-100745         1   016321-017204          1   017205-017227          1   017230-017447          1   017450-020036
1   016022-016320         2   101040-101053                                     2   101054-101140          2   101141-101203
2   100746-101037

NIOINS/RL22               NOUT$ /RL23                NTAB$ /RL22                NBOCVS/RL23                PRCTLG/R
1   020037-020105         0   101235-101242          0   101261-101620          0   101621-102004          0   102005-102063
2   101204-101234         1   020106-021027                                                               1   021030-021104
                          2   101243-101260

PRPTBL/R                  FNDNAM/R                   SRMIOB/R                   DACMUL/R                   DCMMUL/R
0   102004-102143         0   102144-102156          0   102157-102531          0   102532-102541          0   102542-102551
1   021105-021163         1   021164-021227          1   021230-022562          1   022563-022623          1   022624-022660

MTRMJL/R                  CASCDE/R                   ATOZ  /R                   L22BY2/R                   LA2BY2/R
0   102552-102652         0   102653-102672          0   102673-102733          0   102734-102745          0   102746-102757
1   022661-023123         1   023124-023360          1   023361-023606          1   023607-023636          1   023637-023666

MTRMOV/R                  TYPCAL/R                   TYPE25/R                   TYPE24/R                   DCRCIP/R
0   102760-102776         0   102777-103024          0   103025-103045          0   103046-103066          0   103067-103076
1   023667-023735         1   023736-024217          1   024220-024301          1   024302-024401          1   024402-024434

TYPE22/R                  TYPE21/R                   TYPE20/R                   TYPE15/R                   TP1415/R
0   103077-103117         0   103120-103140          0   103141-103227          0   103230-103235          0   103236-103323
1   024435-024533         1   024534-024614          1   024615-025050          1   025051-025075          1   025076-025642
```

DCSNCS/R
0 103324-103343
1 025643-025725

DSHCH /R
0 103344-103361
1 025726-025764

DEXP /RL23
0 103362-103363
1 025765-026123
2 103364-103474

FMATHA/RL22
1 026124-026176
2 103475-103510

DSINCO/RL22
1 026177-026412
2 103511-103562

DCMDIV/R
0 103563-103576
1 026413-026460

T1415S/R
0 103577-103623
1 026461-026723

DSQRT/R
0 103624-103662
1 026724-027155

CS1415/******
0 103663-103666

LZ3BY3/R
0 103667-103700
1 027156-027205

LS1415/R
0 103701-103714
1 027206-027254

CESSFP/******
0 103715-103722

CM1415/******
0 103723-103754

CMN15C/******
0 103755-103756

TYPE14/R
0 103757-103764
1 027255-027301

TYPE11/R
0 103765-104056
1 027302-030316

DCSHCH/R
0 104057-104076
1 030317-030376

DCACSH/R
0 104077-104122
1 030377-030470

DCANG1/R
0 104123-104153
1 030471-030620

DATAN /RL22
1 030621-031016
2 104154-104305

DLOG /RL22
1 031017-031060
2 104306-104371

T11SEP/R
0 104372-104427
1 031061-031355

LDS311/R
0 104430-104443
1 031356-031424

CZ3BY3/******
0 104444-104465

TYPE7 /R
0 104466-104565
1 031425-032261

DECOMB/R
0 104566-105005
1 032262-034163

DLOG10/RL22
1 034164-034202
2 105006-105016

DCMSOL/******
0 105017-105434

DECOND/******
0 105435-105436

VALDET/******
0 105437-105442

TYPE2 /R
0 105443-105564
1 034203-034540

TYPE1 /R
0 105565-105657
1 034541-034755

BLDMTR/R
0 105660-105712
1 034756-035254

FNDMTR/R
0 105713-105726
1 035255-035332

UNPACK/R
0 105727-106054
1 035333-036146

NEXP15/RL22
1 036147-036202
2 106055-106055

C3LD /******
0 106056-106056

CMPZS /R
0 106057-106077
1 036203-036235

PRMARI/R
0 106100-106141
1 036236-036340

FNDTMS/R
0 106142-106172
1 036341-036450

FMFN /R
0 106173-106213
1 036451-036571

PRBFIT/R
0 106214-106265
1 036572-036734

RLIMMG/R
0 106266-106371
1 036735-037141

CGMNPR/******
0 106372-106372

POLED /R
0 106373-106526
1 037142-037504

CMPGAM/R
0 106527-106624
1 037505-037755

PRGMTR/******
0 106625-106625

CMNZS /******
0 106626-106631

LD&M2S/R
0 106632-106714
1 037756-040261

CFLGAZ/******
0 106715-106715

SRCHSB/******
0 106716-106725

PRTMTR/R
0 106726-106754

ZTOA /R
0 106755-107015

CZ2BY2/******
0 107016-107025

CA2BY2/******
0 107026-107035

```
1   040262-040366      1   040367-040614

LOCMTR/R               FNDTL /R               LDOT11/R               LDDRIM/R               CHKSTR/R
0   107036-107052      0   107053-107114      0   107115-107276      0   107277-107311      0   107312-107330
1   040615-040671      1   040672-041075      1   041077-041534      1   041535-041615      1   041616-041646

AIDOD /R               COMN11/******          RDCPRT/R               BLDKKL/R               FNDLCJ/R
0   107331-107355      0   107356-107416      0   107417-107542      0   107543-107631      0   107632-107662
1   041647-042047                             1   042050-043073      1   043074-043513      1   043514-044027

FNDNET/R               CMAGIC/******          CPRTIN/******          CNMRDC/******          LDFREQ/R
0   107663-107710      0   107711-107711      0   107712-107713      0   107714-107715      0   107716-107732
1   044030-044211                                                                           1   044212-044242

HEAD24/R               LDIMTR/R               SKPLIN/R               ALOCAT/R               LDOT7 /R
0   107733-107755      0   107756-110002      0   110003-110014      0   110015-110042      0   110043-110303
1   044243-044365      1   044366-044455      1   044457-044512      1   044513-044575      1   044576-045477

NINPTS/RL23            NININS/RL23            LDOT4 /R               LDOT1 /R               DTASUB/******
0   110304-110305      1   046427-046566      0   110420-110513      0   110514-110636      0   110637-110637
1   045500-046426      2   110341-110417      1   046567-047063      1   047064-047465
2   110306-110340

LDPCPT/R               UPPTBL/R               CPTWRD/******          PRTTBL/******          STRLIN/R
0   110640-110730      0   110731-110756      0   110757-110760      0   110761-113075      0   113076-113122
1   047466-050011      1   050012-050206                                                    1   050207-050223

PAGE  /R               CMNFMN/******          FLGSRH/******          CSRMTR/******          CRMRCT/******
0   113123-113131      0   113132-113134      0   113135-113140      0   113141-113141      0   113142-113145
1   050224-050240

GMECIC/******          CDESGN/******          CFMNPR/******          PRTOFF/******          TOTMAS/******
0   113146-113165      0   113166-113172      0   113173-113173      0   113174-113174      0   113175-113176

TOTL  /******          DTATOT/******          BASIC3/******          CATALG/******
0   113177-113200      0   113201-113201      0   113202-113207      0   113210-114504

END OF ALLOCATION 1103 0039A 0
```

```
******************************************************************************
MOD 9 RUN 80038 APR 23, 1970 $ LIKE MOD 7 RUN 70335
 DESIGN RUN $
LINES OF CONSTANT TAIL LENGTHS
CHARGE TO 16000501 ARRAY DESIGN


* * * * * 9D  7 NETWORK TABLE

S  1970,  -+1T1A,  -+1R2A,$
S  2970,    1E2E,$
S  3970,    2R2A,$
S  4970,    1R2Z,$
S  5970,    2Y2Z,$
S  6970,  -+2E2E,    1V2W,   1Y2Z,$
S  7970,  -+1T13,    2R2Z,   2V2W,$


* * * * * AD  6 NETWORK TABLE

S  1A6D,    3C3D,$
S  2A6D,    5B5D,$
S  3A6D,  -+2C3D,    2B5D,$
S  4A6D,  -+1B5D,    1C3D,$
S  5A6D,  -+3B5D,    1R2D,$
S  6A6D,  -+4B5D,    2R2D,$

TYPE 1          RHO        AREA          ID        OD        LENGTH
E2E1$          4416.90    .148261-01    .000000  .137394    .009070
               C REAL     C IMAG        C MULT                         MASS
               4820.00    .000000       .000000                        .59394

TYPE 1          RHO        AREA          ID        OD        LENGTH
R2A1$          7712.80    .790233-03    .000000  .031720    .007248
               C REAL     C IMAG        C MULT                         MASS
               4970.00    .000000       .000000                        .09412

TYPE 1          RHO        AREA          ID        OD        LENGTH
```

```
[illegible]1S    7702.80    .790233-03   .000000 .031720   .000838
                 C REAL     C IMAG        C MULT                       MASS
                 4970.00     .000000       .000000                     .00510

TYPE 1            RHO        AREA          ID        OD      LENGTH
T231$            7730.00    .228639-02   .000000 .053955   .003357
                 C REAL     C IMAG        C MULT                       MASS
                 4970.00     .000000       .000000                     .05933

TYPE 1            RHO        AREA          ID        OD      LENGTH
T232$            7724.87    .138402-02   .000000 .046305   .003314
                 C REAL     C IMAG        C MULT                       MASS
                 4970.00     .000000       .000000                     .04311

TYPE 1            RHO        AREA          ID        OD      LENGTH
T233$            7719.24    .130699-02   .000000 .040794   .010214
                 C REAL     C IMAG        C MULT                       MASS
                 4970.00     .000000       .000000                     .10305

TYPE 1            RHO        AREA          ID        OD      LENGTH
T254$            7702.80    .790233-03   .000000 .031720   .006679
                 C REAL     C IMAG        C MULT                       MASS
                 4970.00     .000000       .000000                     .04066

TYPE 1            RHO        AREA          ID        OD      LENGTH
V2W1$            4416.90    .112776-01   .000000 .119829   .011370
                 C REAL     C IMAG        C MULT                       MASS
                 4820.00     .000000       .000000                     .56637

TYPE 1            RHO        AREA          ID        OD      LENGTH
V2W2$            4416.90    .112776-01   .000000 .119829   .011370
                 C REAL     C IMAG        C MULT                       MASS
                 4820.00     .000000       .000000                     .56637

TYPE 1            RHO        AREA          ID        OD      LENGTH
V2W3$            7788.48    .254984-02   .000000 .056979   .002224
                 C REAL     C IMAG        C MULT                       MASS
                 5116.00     .000000       .000000                     .04418

TYPE 1            RHO        AREA          ID        OD      LENGTH
```

```
Y221$      2700.81   .348119-02  .000000 .066575  .011370
           C REAL    C IMAG      C MULT                     MASS
           5200.00    .000000     .000000                   .10698

TYPE 1      RHO       AREA        ID       OD     LENGTH
Y222$      2700.81   .348119-02  .000000 .066576  .011370
           C REAL    C IMAG      C MULT                     MASS
           5200.00    .000000     .000000                   .10698

TYPE 4       UNIT MATRIX
Y223$         1.00
```

```
TYPE 7       SCALE      MATRIX    NUMERATOR     DENOMINATOR     SYMMETRY
             FACTOR      FORM       ORDER          ORDER          FLAG
Z24S        .1000+01      0           3              1             -1
      COEF. TO CHECK NEW TYPE 7 WITH OLD TYPE 7
         POLYNOMIAL COEFFICIENTS FOR Z(I,J)=(C0+C1*F+...)/(D0+D1*F+...)

      NUMERATOR  POLYNOMIAL  COEFFICIENTS FOR MATRIX ELEMENT(  1,  1)
           .0000000000       -.8589896000+09
           .0000000000        .7711489900+05
           .0000000000       -.9040960000+01
           .0000000000        .1627919980-02

      DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(  1,  1)
           .5000000000        .0000000000
           .1000000000+01     .0000000000

      NUMERATOR  POLYNOMIAL  COEFFICIENTS FOR MATRIX ELEMENT(  1,  2)
           .0000000000        .8683080000+09
           .0000000000       -.7690410000+05
           .0000000000        .1246709980+02
           .0000000000       -.1530115930-02

      DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(  1,  2)
           .0000000000        .0000000000
           .1000000000+01     .0000000000

      NUMERATOR  POLYNOMIAL  COEFFICIENTS FOR MATRIX ELEMENT(  2,  2)
           .0000000000        .8691160000+09
           .0000000000       -.7743060000+05
           .0000000000       -.2671390000+00
           .0000000000       -.1807459960-02

      DENOMINATOR POLYNOMIAL COEFFICIENTS FOR MATRIX ELEMENT(  2,  2)
           .0000000000        .0000000000
           .1000000000+01     .0000000000

F2S UNIT MATRIX
D2S UNIT MATRIX
S2S UNIT MATRIX
```

```
* * * * * F =   3500.000000 * * * * *


TYPE 1          RHO         AREA          ID        OD       LENGTH
T2A1$          7832.48     .217225-01   .000000 .166307   .038125
               C REAL      C IMAG        C MULT                              MASS
               5116.00      .000000       .000000                            6.48658

REPLACE

TYPE 1          RHO         AREA          ID        OD       LENGTH
Y223$          2702.61     .245000-02   .000000 .035852   .035354
               C REAL      C IMAG        C MULT                              MASS
               5200.00      .000000       .000000                            .23411

TYPE 11         RHO         AREA          ID        OD       LENGTH
C30$           7535.21     .490000-02   .000000 .078987   .013625
               C REAL      C IMAG        C MULT             N PIECES         MASS
               3743.27     .312617+01    .835144-03            2             1.01324

                      REAL                  IMAG                    MULT
          E33T   .1411656000+004   -.3416019970+001    .2419850000-002
          G33    .2452070000-001    .4595841239-005   -.1874270000-003
          S330   .9404950000-011   -.1570899394-013    .1670230000-002

          K33    .6664539643+000   -.6940269089-004

TOTAL LENGTH =  .061285 FOR SECTIONS   VW   EE   CD


TYPE 1          RHO         AREA          ID        OD       LENGTH
R201$          7702.80     .571140-03   .000000 .026967   .053199
               C REAL      C IMAG        C MULT                              MASS
               4970.00      .000000       .000000                            .23404
```

Z SELF

MAG	ANG DEG	REAL	IMAG
.0000000000	.0000000000	.0000000000	.0000000000

L T2A1	A C3D	L C3D	N	TOT MASS	TOT LENGTH	REACTOR	GAMMA IC	GAM EC MIN
.3812-01	.4900-02	.1738+00	N = 12	.1910+02	.3242+00	.4270-01	.1106+08	.1037+03
.3812-01	.6500-02	.2086+00	N = 16	.2315+02	.3590+00	.1997-01	.1231+08	.1373+03
.3812-01	.7520-02	.2259+00	N = 16	.2538+02	.3764+00	.1774-01	.1263+08	.1578+03
.3812-01	.8100-02	.2345+00	N = 18	.2747+02	.3850+00	.1313-01	.1271+08	.1693+03
.3812-01	.1290-01	.2827+00	N = 20	.4116+02	.4331+00	.6547-02	.1210+08	.2626+03
.7625-01	.4900-02	.1291+00	N = 10	.2372+02	.3176+00	.4755-01	.9667+07	.8358+02
.7625-01	.6500-02	.1614+00	N = 12	.2710+02	.3499+00	.2907-01	.1171+08	.1153+03
.7625-01	.7520-02	.1782+00	N = 14	.2944+02	.3668+00	.1945-01	.1249+08	.1355+03
.7625-01	.8100-02	.1868+00	N = 14	.3031+02	.3754+00	.1842-01	.1279+08	.1470+03
.7625-01	.1290-01	.2387+00	N = 18	.4315+02	.4273+00	.7201-02	.1291+08	.2434+03
.1144+00	.4900-02	.1095+00	N = 3	.2939+02	.3362+00	.6387-01	.8577+07	.7236+02
.1144+00	.6500-02	.1385+00	N = 10	.3236+02	.3552+00	.3691-01	.1077+08	.1007+03
.1144+00	.7520-02	.1537+00	N = 12	.3442+02	.3804+00	.2364-01	.1176+08	.1189+03
.1144+00	.8100-02	.1615+00	N = 12	.3563+02	.3882+00	.2252-01	.1219+08	.1293+03
.1144+00	.1290-01	.2096+00	N = 16	.4666+02	.4363+00	.8462-02	.1328+08	.2202+03
.1525+00	.4900-02	.9843-01	N = 8	.3542+02	.3633+00	.5775-01	.7851+07	.6559+02
.1525+00	.6500-02	.1252+00		.3813+02	.3901+00	.3383-01	.1002+08	.9124+02

		N = 10					
.1525+00	.7520-02	.1391+00	.4000+02	.4039+00	.3140-01	.1105+08	.1076+03
		N = 10					
.1525+00	.8100-02	.1461+00	.4111+02	.4110+00	.3002-01	.1154+08	.1171+03
		N = 10					
.1525+00	.1290-01	.1697+00	.5112+02	.4545+00	.1045-01	.1329+08	.1998+03
		N = 14					
.1906+00	.4900-02	.9114-01	.4161+02	.3941+00	.9532-01	.7333+07	.6097+02
		N = 6					
.1906+00	.6500-02	.1163+00	.4414+02	.4192+00	.4949-01	.9430+07	.8459+02
		N = 8					
.1906+00	.7520-02	.1292+00	.4538+02	.4321+00	.2951-01	.1047+08	.9955+02
		N = 10					
.1906+00	.8100-02	.1357+00	.4690+02	.4386+00	.2827-01	.1096+08	.1081+03
		N = 10					
.1906+00	.1290-01	.1753+00	.5612+02	.4782+00	.1359-01	.1311+08	.1831+03
		N = 12					

A Y2Z4

1	1	.9383815355+00	.0000000000
2	1	.0000000000	.5132157777-05
1	2	.0000000000	.5614587184+05
2	2	.7585939197+00	.0000000000

Z Y2Z4

1	1	.0000000000	-.1828434698+06
2	1	.0000000000	-.1946498163+06
1	2	.0000000000	.1946498163+06
2	2	.0000000000	.1478118859+06

* * * * COMMON PRT TBL * * * * *

N	NET SP	I SIGN C	D	J PORT	N PORTS	NET NAM	NUM APO	NUM NPO	N AHEAD	N BACK	LC J ROW
1	S	1	1	1	7	BD	1	-1	4	0	1
2	S	-1	1	1	1	TA	1	1	3	0	858
3	S	-1	1	1	2	RA	1	2	7	2	380
4	S	1	1	2	7	BD	2	-2	6	1	2
5	S	1	1	1	2	EE	2	4	13	7	341
6	S	1	1	3	7	BD	3	-3	8	4	3
7	S	1	1	2	2	RA	3	3	5	3	381
8	S	1	1	4	7	BD	4	-4	10	6	4
9	S	1	1	1	2	RZ	4	6	18	13	419
10	S	1	1	5	7	BD	5	-5	12	8	5
11	S	1	1	2	2	YZ	5	9	14	15	652
12	S	1	1	6	7	BD	6	-6	16	10	6
13	S	-1	1	2	2	EE	6	5	9	5	342
14	S	1	1	1	2	VW	6	10	19	11	566
15	S	1	1	1	2	YZ	6	8	11	18	651
16	S	1	1	7	7	BD	7	-7	20	12	7
17	S	-1	1	1	1	TB	7	12	0	19	862
18	S	1	1	2	2	RZ	7	7	15	9	420
19	S	1	1	2	2	VW	7	11	17	14	567
20	S	1	1	1	6	AD	1	-1	22	16	197
21	S	1	1	3	3	CD	1	3	28	25	1024
22	S	1	1	2	6	AD	2	-2	24	20	198
23	S	1	1	5	5	BD	2	8	32	34	870
24	S	1	1	3	6	AD	3	-3	27	22	199
25	S	-1	1	2	3	CD	3	2	21	29	1023
26	S	1	1	2	5	BD	3	5	31	28	867
27	S	1	1	4	6	AD	4	-4	30	24	200
28	S	-1	1	1	5	BD	4	4	26	21	966
29	S	1	1	1	3	CD	4	1	25	0	1022
30	S	1	1	5	6	AD	5	-5	33	27	201
31	S	-1	1	3	5	BD	5	6	34	26	868
32	S	1	1	1	2	RD	5	9	35	23	1091
33	S	1	1	6	6	AD	6	-6	0	30	202
34	S	-1	1	4	5	BD	6	7	23	31	869

35 5 1 1 2 2 RD 6 10 0 32 1092

* * * * * COMMON CATALG * * * * *

I	NAME	MTR SIZ	I PC	N PC TOT	I TYPE	N DT STR	LOC
1	BD	7	0	0	0	0	1
2	AD	6	0	0	0	0	197
3	EE	2	0	1	0	0	341
4	EE	2	1	1	1	7	357
5	RA	2	0	1	0	0	380
6	RA	2	1	1	1	7	396
7	RZ	2	0	1	0	0	419
8	RZ	2	1	1	1	7	435
9	TB	2	0	4	0	0	458
10	TB	2	1	4	1	7	474
11	TB	2	2	4	1	7	497
12	TB	2	3	4	1	7	520
13	TB	2	4	4	1	7	543
14	VW	2	0	3	0	0	566
15	VW	2	1	3	1	7	582
16	VW	2	2	3	1	7	605
17	VW	2	3	3	1	7	628
18	YZ	2	0	4	0	0	651
19	YZ	2	1	4	1	7	667
20	YZ	2	2	4	1	7	690
21	YZ	2	3	4	1	7	713
22	YZ	2	4	4	7	42	737
23	FS	2	0	0	0	0	795
24	DS	2	0	0	0	0	803
25	SS	2	0	0	0	0	811
26	TA	2	0	1	0	0	819
27	TA	2	1	1	1	7	835
28	TA	1	0	0	0	0	858
29	TB	1	0	0	0	0	862
30	BD	5	0	0	0	0	866
31	BD	0	0	0	0	0	966
32	BD	0	0	0	0	0	982
33	CD	3	0	0	11	33	1022
34	RD	2	0	1	0	0	1091
35	RD	2	1	1	1	7	1107
36	AD	2	0	0	0	0	1130

37	AD	0	0	0	0	0	1146
38	AD	0	0	0	0	0	1210
39	ES	2	0	0	0	0	1242
40	MS	2	0	0	0	0	1250
41	GS	2	0	0	0	0	1258
42	HS	2	0	0	0	0	1266

TOTAL DATA CELLS USED IN MASTER STORAGE 1273

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*********************************************************************************
SEADUCER RUN 80001 (LIKE MOD 7 RUN 70294) SEPT 26,1970
WARDS DUCER FOR MOD 8 DEVELOPMENT (K8D NETWORK)

* * * * * KD  8 NETWORK TABLE

S  1K8D, 1B2G,$
S  2K8D, 2B2B,$
S  3K8D, 3D3A,$
S  4K8D, 1B2B, 1B2C, -+2B2E,$
S  5K8D, 1B1D, -+2B2C, -+2B2R, $
S  6K8D, 1B2F, 1B2R, -+2B2G, $
S  7K8D, 1D3A, -+2B2F, $
S  8K8D, -+2D3A, 1B2E, $

TYPE 1         RHO       AREA        ID      OD      LENGTH
B2B1$        7815.00   .139360-02  .000000 .042214  .121570
             C REAL    C IMAG      C MULT                     MASS
             5116.00    .000000     .000000                  1.32972

TYPE 1         RHO       AREA        ID      OD      LENGTH
B2B2$        7815.00   .810000-02  .000000 .101554  .102400
             C REAL    C IMAG      C MULT                     MASS
             5116.00    .000000     .000000                  6.48207

TYPE 1         RHO       AREA        ID      OD      LENGTH
B2B3$        7815.00   .134200-02  .000000 .041336  .067854
             C REAL    C IMAG      C MULT                     MASS
             5116.00    .000000     .000000                   .71163

TYPE 1         RHO       AREA        ID      OD      LENGTH
B2C1$        7558.40   .101371-02  .000000 .036032  .003175
             C REAL    C IMAG      C MULT                     MASS
             5116.00    .000000     .000000                   .02447

TYPE 4          UNIT MATRIX
B2C2$             1.00
```

```
TYPE 1       RHO          AREA          ID         OD        LENGTH
B2D1$        7746.00      .760378-03    .000000    .031115   .009601
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .05655

TYPE 2       RHO          A1            ID1        OD1
B2D2$        7743.74      .760378-03    .000000    .031115
                          A2            ID2        OD2       LENGTH
                          .455310-03    .000000    .024077   .002540
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .01183

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2D3$        7743.45      .455310-03    .000000    .024077   .003302
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .01164

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2D4$        7737.80      .240258-03    .000000    .017490   .003600
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .00669

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2R1$        7738.00      .240258-03    .000000    .017490   .010500
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .01952

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2R2$        7738.00      .285023-03    .000000    .019050   .035250
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .07774

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2R3$        7738.00      .197933-03    .000000    .015875   .474537
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .72680

TYPE 1       RHO          AREA          ID         OD        LENGTH
B2R4$        7738.00      .285023-03    .000000    .019050   .037230
             C REAL       C IMAG        C MULT                           MASS
             4970.00      .000000       .000000                          .03224
```

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```
TYPE 1         RHO       AREA         ID       OD       LENGTH
B2R5$        7738.00   .240258-03   .000000  .017490   .008246
             C REAL    C IMAG       C MULT                          MASS
             4970.00    .000000      .000000                        .01533

TYPE 4          UNIT MATRIX
B2E1$            1.00

TYPE 1         RHO       AREA         ID       OD       LENGTH
B2E2$        7814.88   .426383-02   .000000  .073681   .031750
             C REAL    C IMAG       C MULT                          MASS
             5116.00    .000000      .000000                       1.05795

TYPE 1         RHO       AREA         ID       OD       LENGTH
B2F1$        7802.15   .456037-02   .000000  .076200   .031750
             C REAL    C IMAG       C MULT                          MASS
             5116.00    .000000      .000000                       1.12969

TYPE 1         RHO       AREA         ID       OD       LENGTH
B2G1$        7815.00   .260000-02   .000000  .057536   .010520
             C REAL    C IMAG       C MULT                          MASS
             5116.00    .000000      .000000                        .21376

TYPE 1         RHO       AREA         ID       OD       LENGTH
B2G2$        7815.00   .215000-02   .000000  .052321   .021340
             C REAL    C IMAG       C MULT                          MASS
             5116.00    .000000      .000000                        .35856

TYPE 11        RHO       AREA         ID       OD       LENGTH
D3A$         7440.00   .253354-02   .000000  .056796   .019198
             C REAL    C IMAG       C MULT            N PIECES      MASS
             3479.30   .482230+01   .138600-02           26        9.40871

                   REAL               IMAG                MULT
          E33T   .1280390000+004   -.1771470370+001   .1363000000-002
          G33    .2378780000-001   -.1207944484-004   .5076000000-003
           3D    .1110300000-010   -.3077751600-013   .7720000000-002

          K33    .6052162048+000    .7160454537-004
```

```
REPLACE

TYPE 4      UNIT MATRIX
B2E2$         1.00

REPLACE

TYPE 1       RHO        AREA          ID        OD      LENGTH
B2E1$      7814.88   .426383-02   .000000  .073681   .031750
           C REAL     C IMAG        C MULT                        MASS
           5116.00    .000000       .000000                     1.05795

REPLACE

TYPE 2       RHO         A1           ID1       OD1
B2D2$      7743.74   .760378-03   .000000  .031115
                         A2           ID2       OD2     LENGTH
                     .455310-03   .000000  .024077   .002540
           C REAL     C IMAG        C MULT                        MASS
           4970.00    .000000       .000000                      .01183

REPLACE

TYPE 1       RHO        AREA          ID        OD      LENGTH
B2D4$      7737.80   .240258-03   .000000  .017490   .003600
           C REAL     C IMAG        C MULT                        MASS
           4970.00    .000000       .000000                      .00669

REPLACE

TYPE 1       RHO        AREA          ID        OD      LENGTH
B2B1$      7815.00   .139960-02   .000000  .042214   .121570
           C REAL     C IMAG        C MULT                        MASS
           5116.00    .000000       .000000                     1.32972

REPLACE

TYPE 11      RHO        AREA          ID        OD      LENGTH
?3A$       7440.00   .253354-02   .000000  .056796    019198
           C REAL     C IMAG        C MULT          N PIECES      MASS
           [illegible] [illegible]  [illegible]     [illegible]   [illegible]
```


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	REAL	IMAG	MULT
E33T	.1280890000+004	-.1771470870+001	.1383000000-002
G33	.2378720000-001	-.1207944484-004	.5078000000-003
S33D	.1110300000-010	-.3077751600-013	.2772000000-002
K33	.6052162044+000	.7160454537-004	

TOTAL MASS = 21.72491 KG.   47.89518 LBS.

TOTAL LENGTH = .886332 FOR SECTIONS   BG   BF   DA   BE   BB

• • • • • F =   2500.000000 • • • • •

FINAL K3D MATRIX

1	1	.8246889136+03	-.9647054664+05
2	1	-.8518089926+03	.1639490892+06
3	1	.5459747956+02	-.1129571571+05
1	2	.8518089926+03	-.1639490892+06
2	2	-.1464582941+04	.8957370445+05
3	2	.5914333365+02	-.1980984506+04
1	3	.5459747956+02	-.1129571571+05
2	3	-.5914333365+02	.1980984506+04
3	3	.5935133270+01	-.2570213422+04

Z K2D MATRIX

1	1	.4594277801+03	-.4682782852+05
2	1	-.5699045679+03	.1552435546+06
1	2	.5699045679+03	-.1552435546+06
2	2	-.1376936933+04	.8804802498+05

* * * * * COMMON PRT TBL * * * * *

N	NET SP	I SIGN C	D	J PORT	N PORTS	NET NAM	NUM APO	NUM NPO	N AHEAD	N BACK	LC J ROW
1	S	1	1	1	8	KD	1	-1	3	0	1
2	S	1	1	1	2	BG	1	1	18	0	7
3	S	1	1	2	8	KD	2	-2	5	1	2
4	S	1	1	2	2	BB	2	4	20	6	253
5	S	1	1	3	8	KD	3	-3	7	3	3
6	S	1	1	3	3	DA	3	7	9	23	811
7	S	1	1	4	8	KD	4	-4	11	5	4
8	S	1	1	1	2	BB	4	3	4	18	257
9	S	1	1	1	2	BC	4	8	13	6	342
10	S	-1	1	2	2	BE	4	11	12	24	646
11	S	1	1	5	8	KD	5	-5	15	7	5
12	S	1	1	1	1	BD	5	12	17	10	878
13	S	-1	1	2	2	BC	5	9	24	9	343
14	S	-1	1	2	2	BR	5	14	16	17	515
15	S	1	1	6	8	KD	6	-6	19	11	6
16	S	1	1	1	2	BF	6	15	21	14	708
17	S	1	1	1	2	BR	6	13	14	12	514
18	S	-1	1	2	2	BG	6	2	8	2	748
19	S	1	1	7	8	KD	7	-7	22	15	7
20	S	1	1	1	3	DA	7	5	23	4	809
21	S	-1	1	2	2	BF	7	16	0	16	709
22	S	1	1	8	8	KD	8	-8	0	19	8
23	S	-1	1	2	3	DA	8	6	6	20	810
24	S	1	1	1	2	BE	8	10	10	13	645

* * * * * COMMON CATALG * * * * *

I	NAME	MTR SIZ	I PC	N PC TOT	I TYPE	N DT STR	LOC
1	KD	8	0	0	0	0	1
2	BB	2	0	3	0	0	257
3	BB	2	1	3	1	7	273
4	BB	2	2	3	1	7	296
5	BB	2	3	3	1	7	319
6	BC	2	0	2	0	0	342
7	BC	2	1	2	1	7	358
8	BC	2	2	2	4	8	381
9	BD	2	0	4	0	0	405
10	BD	2	1	4	1	7	421
11	BD	2	2	4	2	8	444
12	BD	2	3	4	1	7	468
13	BD	2	4	4	1	7	491
14	BR	2	0	5	0	0	514
15	BR	2	1	5	1	7	530
16	BR	2	2	5	1	7	553
17	BR	2	3	5	1	7	576
18	BR	2	4	5	1	7	599
19	BR	2	5	5	1	7	622
20	BE	2	0	2	0	0	645
21	BE	2	1	2	1	7	661
22	BE	2	2	2	4	8	685
23	BF	2	0	1	0	0	708
24	BF	2	1	1	1	7	724
25	BG	2	0	2	0	0	747
26	BG	2	1	2	1	7	763
27	BG	2	2	2	1	7	785
28	DA	3	0	0	11	33	809
29	BD	1	0	0	0	0	878
30	KD	3	0	0	0	0	882
31	KD	0	0	0	0	0	918
32	KD	0	0	0	0	0	1018
33	KD	2	0	0	0	0	1078
34	KD	0	0	0	0	0	1094
35	KD	0	0	0	0	0	1098

TOTAL DATA CELLS USED IN MASTER STORAGE 1105

Radian Corporation 8500 SHOAL CREEK BLVD. • P. O. BOX 9948 • AUSTIN, TEXAS 78766 • TELEPHONE 512 - 454-9535

Appendix B

Scattering from Translucent Baffles

Radian Corporation 8500 SHOAL CREEK BLVD. • P. O. BOX 9948 • AUSTIN, TEXAS 78766 • TELEPHONE 512-454-9535

Scattering from Translucent Baffles

The purpose of this discussion is to outline an approach for treating the combined effects of transmission and edge diffraction for plane wave scattering from a planar baffle. The scope of the discussion includes a brief description of an integral formulation of the problem and some of the difficulties inherent in an approximate approach.

A rigorous formulation of the problem of interest differs from that of an opaque baffle in the requirement of characterizing the response of the baffle material to a distribution of forces on its surfaces. In effect, this requirement is equivalent to the determination of a Green's function or "influence" function for the baffle material.*

Knowing the influence function for the baffle material, one can write an integral relationship between the force distribution on the baffle surfaces and the velocity field on the baffle surface. Since the baffle is immersed in a fluid which is assumed inviscid, the force at a given point on the baffle is normal to the surface. Consequently, the normal velocity $V_n(\vec{r})$ at a point $\vec{r}$ on the baffle surface depends on the normal force per unit area, i.e., the pressure, p, according to the relation:

$$V_n(\vec{r}) = \int_{S_b} K(\vec{r}|\vec{r}\,')p(\vec{r}\,')dS' \quad , \qquad \text{(B-1)}$$

---

* See Sec. IV of Ref. [B-1] for an analogous approach to transducer dome interaction.

where $K(\vec{r}|\vec{r}\,')$ is the n-n component of the influence dyadic [B-1] for the baffle material. The integral in Equation (B-1) is taken over both sides of the baffle.

It is important to note that the kernel, $K(\vec{r}|\vec{r}\,')$, depends only on the geometrical and physical properties of the baffle, i.e., it is independent of the conditions existing at any point of the fluid in which the baffle is immersed. Also we note that Equation (B-1) is a generalized impedance relationship; more correctly $K(\vec{r}|\vec{r}\,')$ has the units of an admittance per unit area. As such, Equation (B-1) is a mathematical formulation of the transmissive properties of the baffle material. Furthermore, any baffle material having linear constitutive equations gives rise to an impedance relationship of the form given in Equation (B-1)*, i.e., the form of Equation (B-1) does not depend on any assumptions regarding baffle geometry.

To complete the specification of the scattering of a plane wave

$$p_i(\vec{r}) = e^{i\vec{k}\cdot\vec{r}} \tag{B-2}$$

by the baffle, we use the Helmholtz representation of the total field:

$$p(\vec{r}) = p_i(\vec{r}) + \int_{S_b} \left[p(\vec{r}\,') \frac{\partial g}{\partial n'}(\vec{r}|\vec{r}\,') - \frac{\partial p}{\partial n'}(\vec{r}\,') g(\vec{r}|\vec{r}\,') \right] dS' \quad , \tag{B-3}$$

* For cases of locally reacting surfaces, the kernel is proportional to a (surface) "delta function".

where $p(\vec{r})$ is the total pressure field at the point $\vec{r}$ in the fluid, and g is the free space Green's function for the fluid medium.[B-1]

The above relationships, in conjunction with the definition

$$V_n(\vec{r}) = \frac{1}{ik\rho c} \frac{\partial p}{\partial n}(\vec{r})\Big]_{S_b} , \qquad \text{(B-4)}$$

where k is the wave number and ρc is the fluid, acoustical impedance, serve to define a solution to the problem. In particular, Equation (B-1), and the limiting form of Equation (B-3) as the field point $\vec{r}$ approaches the baffle surface, give rise to a pair or coupled integral equations which, by virtue of Equation (B-4), relate the unknown pressure and velocity fields on the baffle surface, p and V_n, respectively, to the incident pressure field p_i. A simultaneous solution of these integral equations defines the terms appearing in the integral of Equation (B-3), hence Equation (B-3) defines the pressure field at every point in the fluid.

While the above approach is conceptually applicable to general baffle shapes in either two or three dimensions, the practical aspects of implementing the formalism is limited first of all to baffles for which the influence function can be evaluated analytically and secondly by computational difficulties of obtaining an approximate solution to the coupled integral equations.*

In view of the difficulties mentioned, it would be desirable to have an alternative, approximate approach to represent the essential features of the pressure field. In order to

* Additionally the formalism would need to be modified for treating "reasonance" wave numbers associated with the baffle.

derive such an approximation it is necessary to limit the discussion to specialized geometrical configurations. In particular, we limit the subsequent discussion to the case of a planar baffle.

As a first approximation, we assume that the pressure and velocity fields on the baffle surfaces are not influenced appreciably by the presence of the edge. This assumption corresponds in some sense to the Kirchhoff approximation used previously for analysis of opaque baffles. Furthermore, the assumption enables one to write

$$p(\vec{r}\,')\Big]_{S_b} = \begin{cases} e^{i\vec{k}\cdot\vec{r}} + R(\vec{k})e^{i\vec{k}_1\cdot\vec{r}} & \text{on } S_i \\ T(\vec{k})e^{i\vec{k}\cdot\vec{r}} & \text{on } S_s \end{cases} \qquad \text{(B-5)}$$

where $R(\vec{k})$, $T(\vec{k})$ denote, respectively, the (amplitude) reflection and transmission coefficients for a layer of the baffle material which incorporate the physical properties of the baffle*, $\vec{k}_1$ denotes the propagation vector of the reflected wave, S_i denotes the illuminated baffle surface, and S_s denotes the shadow baffle surface. In writing the above relationship, we have implicitly assumed the baffle thickness is negligible relative to the acoustical fluid wavelength. This assumption simplifies the discussion and can easily be removed.

---

* See Reference B-2 for the definition of the transmission and reflection coefficients for a composite layer.

If, in addition to Equation (B-5), we assume an analogous equality for the normal derivative on the baffle surface, then the resulting approximate pressure field takes the form:

$$p(\vec{r}) = e^{i\vec{k}\cdot\vec{r}} + \left[1 - T(\vec{k})\right]U(\vec{r}|\vec{k}) + R(\vec{k})U(\vec{r}|\vec{k}_1) \qquad \text{(B-6)}$$

where

$$U(\vec{r}|\vec{k}) = \int_{S_s} \left[g(\vec{r}|\vec{r}\,')\frac{\partial}{\partial n'} e^{i\vec{k}\cdot\vec{r}\,'} - e^{i\vec{k}\cdot\vec{r}\,'}\frac{\partial g}{\partial n'}(\vec{r}|\vec{r}\,')\right]dS' \quad . \qquad \text{(B-7)}$$

The above relationships result from substituting Equations (B-2), (B-5) into Equation (B-3) and using the fact that the integral over S_i is the negative of the integral over S_s because of the assumption of negligible thickness of the baffle.

As in the case for opaque baffles, the approximation scheme described above gives rise to an approximate Green's function which violates the reciprocity principle. It has been noted previously (B-4) that the problem of plane wave scattering corresponds to a limiting process on the Green's function in which the source point moves to infinity. Furthermore physical considerations have indicated that for an opaque baffle, a more accurate approximation for plane wave scattering can be obtained from a Kirchhoff approximation to the Green's function by interchanging field and source coordinates before taking the limit. Whether this holds true for the present approximation remains to be investigated, but the assumption that it does gives rise to an approximation which replaces Equation (B-6) by an integral representation which involves reflection and transmission coefficients

integrated over all angles. This form arises by using the plane wave integral representation for the Green's function given in Reference B-2. Presumably, the latter approximation accounts partially for the fact that the presence of the edge modifies the source strengths appearing in Equation (B-3) from the zero order approximation given by Equation (B-5). This point requires more investigation. In the final analysis it may be required to check any approximation with the pair of coupled integral equations for justification of the assumptions.

The above relationships represent approximate expressions for the pressure field which are applicable to either plates or strips. In the former case g denotes the three-dimensional free space Green's function and the integral is taken over the shadowed surface of the plate.* In the latter case, the integral can be considered as one-dimensional with g denoting the two-dimensional Green's function:

$$g(\vec{r}|\vec{r}\,') = \frac{i}{4} H_0(k|\vec{r}-\vec{r}\,'|) \qquad \text{(B-8)}$$

with H_0 denoting the zero order Hankel function of the first kind.

* The functional form of the integral in Equation (B-7) is such that its value is determined strictly by the edge line of the plate.

The subsequent discussion is concerned with a specialization of Equations (B-6) and (B-7) for the case of a strip baffle.

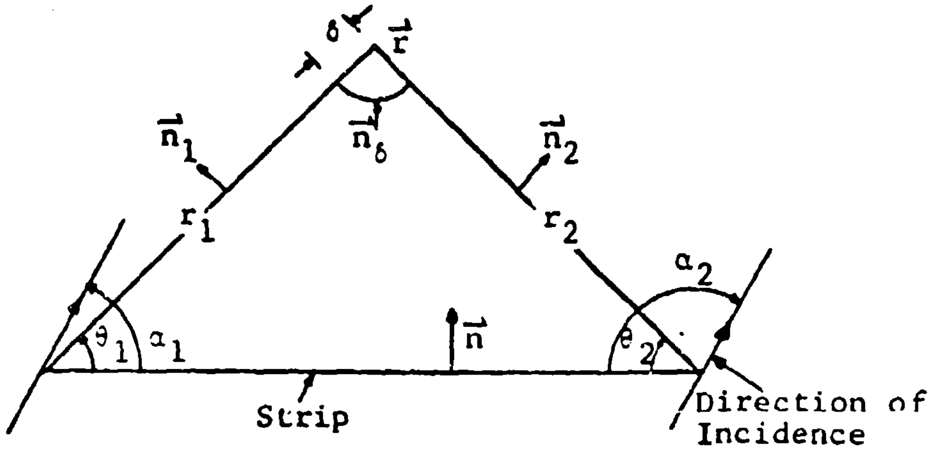

FIG. B-1 - GEOMETRY OF PLANE WAVE SCATTERING FROM A STRIP

Consider the geometrical situation depicted in Figure B-1. It is convenient to reference the arbitrary field point $\vec{r}$ relative to both edges in terms of two systems of cylindrical coordinates as indicated in Figure B-1.

To evaluate Equation (B-7), we make use of the fact that the line integral can be taken over any contour having its end points on the edges of the strip and lying on the same side of the field point as the strip. In particular, the contour can be taken to consist of S_1: the straight line from the left edge to the point a small distance δ from the field point as indicated in Figure B-1; S_δ: the portion of a circle of radius δ centered at the field point and contained between rays from the field point passing through the edges of the strip; S_2: the straight line joining the field point to the right-hand baffle edge taken from a distance δ away from the field point to the right-hand edge.

It is important to note that the contribution from S_δ does not vanish as the radius δ shrinks to zero. The simplest means of evaluating this limit is to recognize that it is equal to the limit for the integral taken over an entire circle multiplied by the ratio of the angle subtended by S_δ and 2π. Recognizing that the angle subtended at $\vec{r}$ by S_δ is $\pi - \theta_1 - \theta_2$, and that the limit over the entire circle is $-e^{-i\vec{k}\cdot\vec{r}}$ according to the Helmholtz integral formula, we obtain

$$U_\delta \xrightarrow[\delta\to 0^+]{} - \left[\frac{\pi - \theta_1 - \theta_2}{2\pi}\right] e^{i\vec{k}\cdot\vec{r}} \quad .$$

Also by observing that on S_1 the normal derivative of G is identically zero we find in the limit as δ approaches zero that

$$U_1 \xrightarrow[\delta\to 0^+]{} \left[\frac{\sin(\theta_1-\alpha_1)}{4} \int_0^{kr_1} dt\, H_o(t) e^{-it\cos(\theta_1-\alpha_1)}\right] e^{i\vec{k}\cdot\vec{r}} \quad ,$$

where we have used Equation (B-3) and the fact that $\vec{k}$ has an angular orientation α_1 relative to the left-hand edge.

A similar result is obtained for the right-hand edge except that the angles are referenced with the subscript 2. Combination of the results gives

$$U(\vec{r}|\vec{k}) = e^{i\vec{k}\cdot\vec{r}} \left[\frac{\theta_1 + \theta_2 - \pi}{2\pi} + \frac{\sin\psi_1}{4}\int_0^{kr} dt\, H_o(t) e^{-it\cos\psi_1}\right.$$

$$\left. + \frac{\sin\psi_2}{4}\int_0^{kr_2} dt\, H_o(t) e^{-it\cos\psi_2}\right] \quad , \qquad \text{(B-9)}$$

where

$$\psi_1 = \theta_1 - \alpha_1, \quad \psi_2 = \theta_2 - \alpha_2 \ .$$

A method of evaluating the integrals in Equation (B-9) has already been discussed in the appendix of Reference B-3. An alternative means of evaluation will be discussed subsequently, but first it is convenient to consider the limiting case of Equation (B-9) as the right-hand edge moves to infinity keeping the field point $\vec{r}$ fixed. According to Figure B-1 this amounts to letting r_2 approach infinity and simultaneously allowing θ_2 to approach zero. Thus

$$\lim_{\substack{r_2\to\infty \\ \theta_2\to 0}} U(\vec{r}|\vec{k}) = e^{i\vec{k}\cdot\vec{r}}\left[\frac{\theta_1 - \pi}{2\pi} + \frac{\sin\psi_1}{4}\int_0^{kr_1} dt\, H_o(t)e^{-it\cos\psi_1} - \frac{\sin\alpha_2}{4}\int_0^{\infty} dt\, H_o(t)e^{-it\cos\alpha_2}\right] .$$

Using the integral representation of the Hankel function and rotating the contour in the t- plane by 90° it may be shown that

$$\frac{\sin\alpha}{4}\int_0^{\infty} dt\, H_o(t)e^{it\cos\alpha} = \frac{\alpha}{2\pi} \quad \text{for } -\pi \le \alpha \le \pi, \text{ and periodic outside this interval.} \qquad \text{(B-10)}$$

This result in conjunction with the identity $\alpha_2 = \pi - \alpha_1$ eivdent from Figure B-1 gives:

$$\lim_{\substack{r_2 \to \infty \\ \theta_2 \to 0}} U(\vec{r}|\vec{k}) = u(kr_1, \psi_1)e^{-i\vec{k}\cdot\vec{r}} , \qquad \text{(B-11)}$$

where

$$u(kr_1, \psi_1) = \frac{\psi_1 - \pi}{2\pi} + \frac{\sin\psi_1}{4} \int_0^{kr_1} dt\, H_o(t)e^{-it\cos\psi_1} , \qquad \text{(B-12)}$$

the above relation being valid under the assumption that α_1 is less than π. A similar analysis shows

$$\lim_{\substack{r_1 \to \infty \\ \theta_1 \to 0}} U(\vec{r}|\vec{k}) = u(kr_2, \psi_2)e^{-i\vec{k}\cdot\vec{r}} . \qquad \text{(B-13)}$$

The relation (B-12) is the same as Equation (3.23) derived by a different method in Reference B-5 if we recognize that Reference B-5 uses the complement of ψ_1. It corresponds to the field diffracted by the edge of a black half-plane the geometric shadow occurring for $\psi_1 \leq 0$.

Furthermore we have according to Equations (B-9), (B-11), (B-12), and (B-13) that

$$U(\vec{r}|\vec{k}) = e^{-i\vec{k}\cdot\vec{r}}\left[1 + u(kr_1, \psi_1) + u(kr_2, \psi_2)\right] ,$$

which in conjunction with Equation (B-7) shows that the field is the superposition of the effects from the two edges.

Making use of Equation (B-10) it follows that Equation (B-12) can be written as

$$u(kr,\psi) = f(\psi) - \frac{\sin\psi}{4}\int_{kr}^{\infty} dt\ H_o(t)e^{-it\cos\psi} , \quad \text{(B-14)}$$

where

$$f(\psi) = \begin{cases} 0 & \psi > 0 \\ -1 & \psi < 0 \end{cases} .$$

A simple approximation to the integral in Equation (B-14) can be obtained by using the asymptotic form of the Hankel function to get

$$v(kr,\psi) = \frac{\sin\psi}{4}\int_{kr}^{\infty} dt\ H_o(t)e^{-it\cos\psi}$$

$$\approx \frac{\sin\psi}{4} \quad \frac{2}{\pi}\ e^{-i(\pi/4)} \int_{kr}^{\infty} dt\ \frac{e^{i(1-\cos\psi)t}}{\sqrt{t}} .$$

Or

$$v(kr\ \ \psi) \approx \cos(\frac{\psi}{2})\left[\frac{1-i}{2}\int_{x}^{\infty} dt\ e^{i(\pi/2)t^2}\right] , \quad \text{(B-15)}$$

where

$$x = 2\sqrt{\frac{kr}{\pi}}\ \sin\psi/2 . \quad \text{(B-16)}$$

Equation (B-16) is valid only for $\psi \geq 0$ and we use the fact that the original expression is odd to determine the approximate representation in the shadow. Note that curves of constant x are parabolic.

While Equation (B-16) is strictly valid only for kr large relative to unity, in practice the approximation compares well with the previous representation given in Reference B-3 for distances greater than 2 or 3 wavelengths. Furthermore a slight modification of the previous analysis shows that applying the approximation in Equation (B-16) to the case of a black half-plane gives a pressure field in the shadow region that differs from the Sommerfeld function[B-6] by the factor cos $\psi/2$.

The above relationships provide an approximate representation for the scattering from a translucent strip baffle which is straightforward from a computational point of view. Furthermore it is not difficult to show that Equation (B-6) reduces to the solution for an infinite planar baffle as the edges of the strip move to infinity. This fact can be obtained most simply by recognizing that for this case the integral in Equation (B-7) can be evaluated in terms of the Helmholtz integral formula if one recognizes that the integral over a large semicircle drawn in the shadow region vanishes. Consequently we find

$$U(\vec{r}|\vec{k}) = \begin{cases} -e^{i\vec{k}\cdot\vec{r}} & \text{in the shadow} \\ 0 & \text{in the illuminated region} \end{cases}$$

$$U(\vec{r}|\vec{k}_1) = \begin{cases} 0 & \text{in the shadow} \\ e^{i\vec{k}_1\cdot\vec{r}} & \text{in the illuminated region.} \end{cases}$$

Substitution of these relations into Equation (B-6) gives the usual results for an infinite planar baffle.

Previous investigations(B-3),(B-4) concerning diffraction from opaque baffles have shown that the diffracted field computed according to the above approach gives good agreement with known exact results for strip baffles greater than or equal to four wavelengths.* Consequently one might expect similar criteria to apply also in the present case. On the other hand, it should be noted that the above approximation does not account for the additional structural modes of vibration resulting from the boundary conditions on the plate edges which are not present in an infinite plate. The extent to which these modes affect the pressure field in the vicinity of a finite plate remains to be investigated.

* Note that an opaque baffle can be characterized in terms of Equation (B-6) by setting the transmission coefficient to zero and the reflection coefficient to plus or minus unity.

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